

# **HRRR 2014 MID-SEASON EVALUATION**

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## **1. Introduction**


This is a 2014 mid-season internal assessment of the HRRR configuration, reliability and performance for the 2014 warm season evaluation period.

## **2. RAP / HRRR changes for 2013**

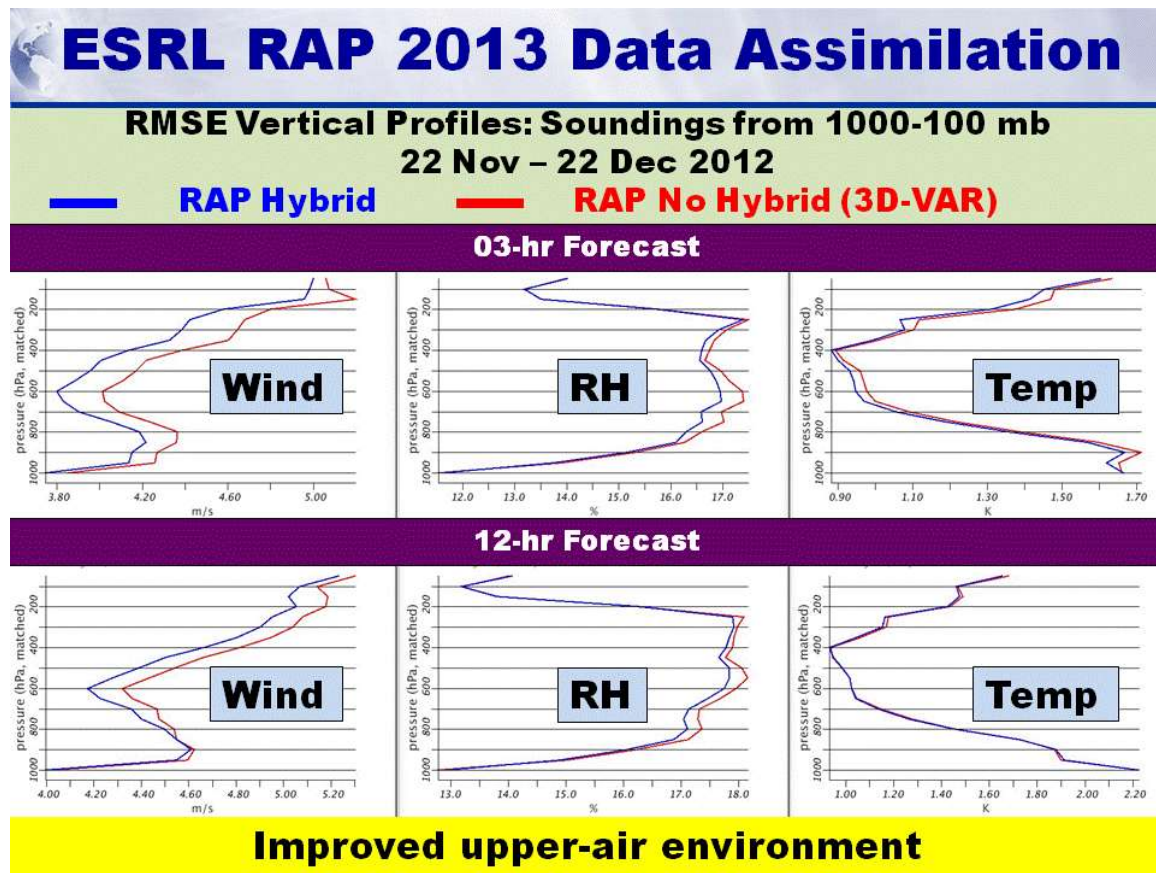
An ambitious set of changes was undertaken for the 2013 year, including upgrades to both the model and data assimilation components for both the RAP and HRRR. A very desirable outcome of completing this set of changes in time for the 2013 warm season, is that were in place and tested in time to be included in the set of changes for the NCEP operational upgrade to the RAP (from RAPv1 to RAPv2) planned for late 2013 and for the initial NCEP implementation of the HRRR (planned for Q2 2014). Table 1 provides list of the key changes and a more detailed description of the changes is given in Appendix A. Key change highlights include an upgrade to the RAP data assimilation from traditional 3DVAR to a 3DVAR-hybrid ensemble assimilation, the additional of a 3-km radar reflectivity assimilation package in the HRRR, and an upgrade from an MYJ PBL scheme to an MYNN scheme and an upgrade to the land surface model (LSM) used in the RAP and HRRR. Also included in these changes was an update to both the WRF-ARW model and GSI analysis package to more recent versions from the community-based SVN repository (a yearly occurrence to make sure the RAP and HRRR system continue to incorporate the latest contributions from the WRF ARW and GSI development communities).

Specific forecast improvements related to specific enhancements include a significant reduction in upper level wind, temperature, and moisture errors (relative to radiosonde observations) associated with the 3DVAR-ensemble hybrid and a reduction in short-term (0-3 hr) HRRR reflectivity errors (relative to observed radar reflectivity mosaic data) associated with the 3-km radar reflectivity assimilation. This last result is especially significant as it represents a significant reduction of the storm spin-up issue in the HRRR. Another extremely important byproduct of the 3-km radar reflectivity assimilation is an approximate 45 min. reduction in the model latency, with 2-h HRRR forecast now available by about +1:15 after the model initial. This reduction in model latency, combined with the improvement in short-range forecast skill, makes the HRRR much more competitive with advanced radar extrapolation-based nowcast systems.

**Table 1. Set of changes to RAP and HRRR model and data assimilation included in the updated version of the GSD real-time experimental RAP / HRRR system used for the 2013 warm season evaluation (also to be included in the upcoming NCEP operational upgrade to RAPv2 and initial implementation of the HRRR).**

 <b>RAP/HRRR Changes as of 10 Apr 2013</b>		
	<b>Model</b>	<b>Data Assimilation</b>
<b>RAP-ESRL (13 km)</b>	WRFv3.4.1+ incl. physics changes (incl. snow-radiation fix) <u>Physics changes:</u> MYNN PBL scheme –Olson version 9-layer RUC LSM (from 6-layer) Modified roughness length Thompson microphysics update Updated reflectivity diagnostic	Merge with GFS trunk GFS ensemble background error cov Stronger/symmetric soil adjustment, adapted for 9-layer LSM Radar hydrometeor building/clearing Snow cover building (added) /modified trimming (no low-level temp limit) Fractional cloud assimilation
<b>HRRR (3 km)</b>	WRFv3.4.1+ incl. physics changes (incl. snow-radiation fix) <u>Physics changes:</u> MYNN PBL scheme –Olson version 9-layer RUC LSM (from 6-layer) Modified roughness length Thompson microphysics update Updated reflectivity diagnostic	3-km/15 min radar reflectivity assim  3-km GSI full-data assim for last pass, including 3-km hydrometeor assim

These changes were extensively evaluated in both retrospective experiments and real-time parallel cycles, before the early April code freeze for the 2013 warm season evaluation. An example of this testing protocol is the time-line for the upgrade from the 3DVAR assimilation to the 3DVAR-ensemble hybrid assimilation, making use of the global ensemble assimilation system files. The possibility for making this enhancement was grown out of discussions with NCEP/EMC colleagues during a visit to NCEP in early in the fall of 2012. Arrangements were then made to gain access to the needed global ensemble files and the code and script work within the RAP for the upgrade were completed by mid-fall and off-line and retrospective testing was completed. Following this, the change was implemented in one of the GSD RAP real-time developmental versions and real-time verification comparisons with operational RAP completed. Fig. 2 shows an example of these verification statistics, upper-level radiosonde verification for wind, temperature, and moisture. As can be seen the 3DVAR-ensemble hybrid errors were substantially reduced from the operational, confirming this change as an upgrade for inclusion in the RAP.

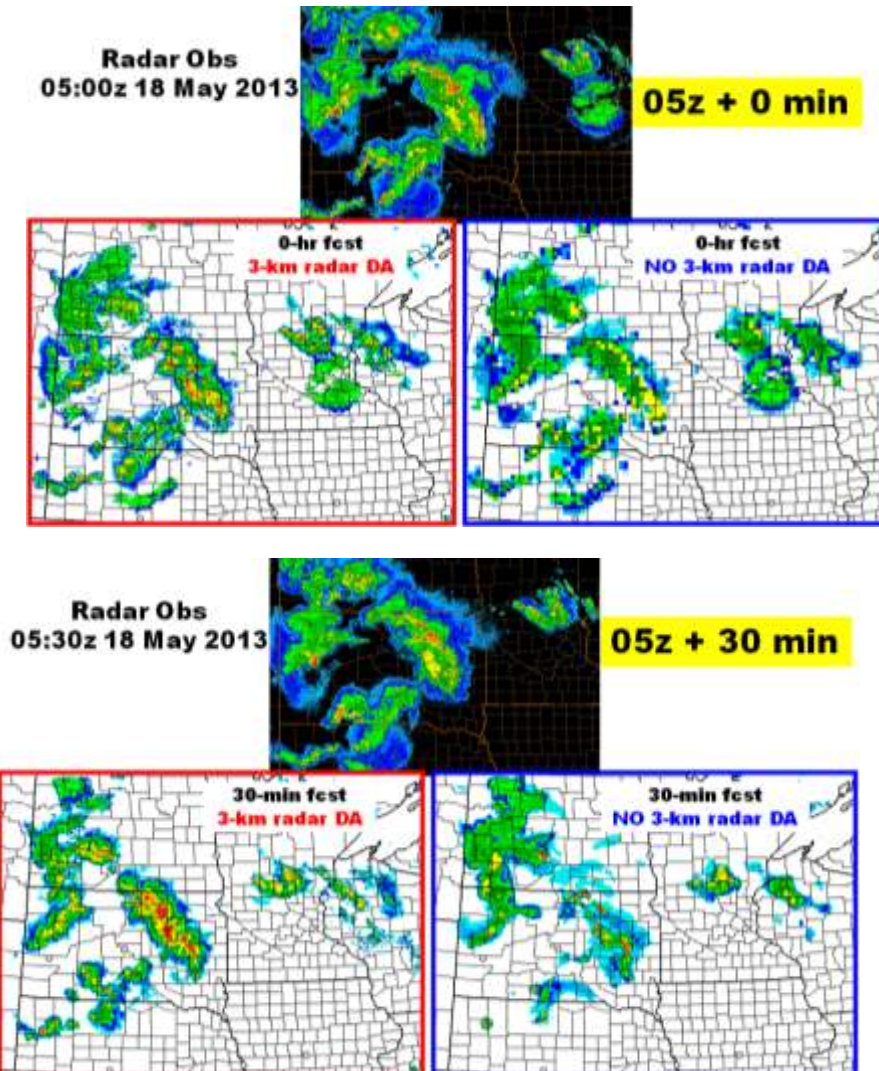


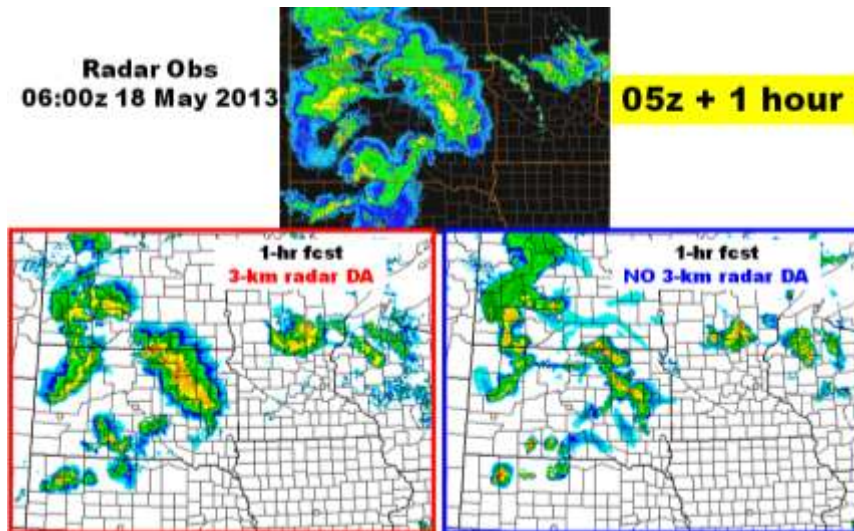
**Fig 1. Comparison of RAP upper-level verification (wind, relative humidity, temperature) against radiosonde observations for retrospective runs with the hybrid 3DVAR / ensemble data assimilation procedure (blue) and without the hybrid procedure (just 3DVAR).**

The other most significant change was the addition of a 3-km radar assimilation procedure (and application of the 3DVAR and cloud analysis on the HRRR domain) within a pre-forecast hour of integration for the a 3-km HRRR. This change significantly reduced the HRRR model spin-up for storms and precipitation systems, leading to improved 0-3 hr storms forecasts. An example of the improvement can be seen in Fig. 2, an illustration of the 0-1 hr. HRRR forecast evolution for runs with and without the 3-km radar reflectivity assimilation (both experiments have the 13-k radar reflectivity assimilation). As can be seen in the Fig. the experiment with the 3-km and 13-km reflectivity assimilation (on the left) is well spun-up mat the 0-h time because the model has been integrating for an hour with the heating from the observed radar data. For the experiment with only the 13-km reflectivity assimilation, the HRRR has a strong convergence signal from the 13-km assimilation (not apparent in the reflectivity plots), but the reflectivity takes some time to develop in response this heating (as can be seen in the plots on the right). Another important advantage of the 3-km radar reflectivity assimilation is it allows the



model run to be started nearly an hour earlier, leading to a ~ 45 min. reduction in the HRRR model latency.

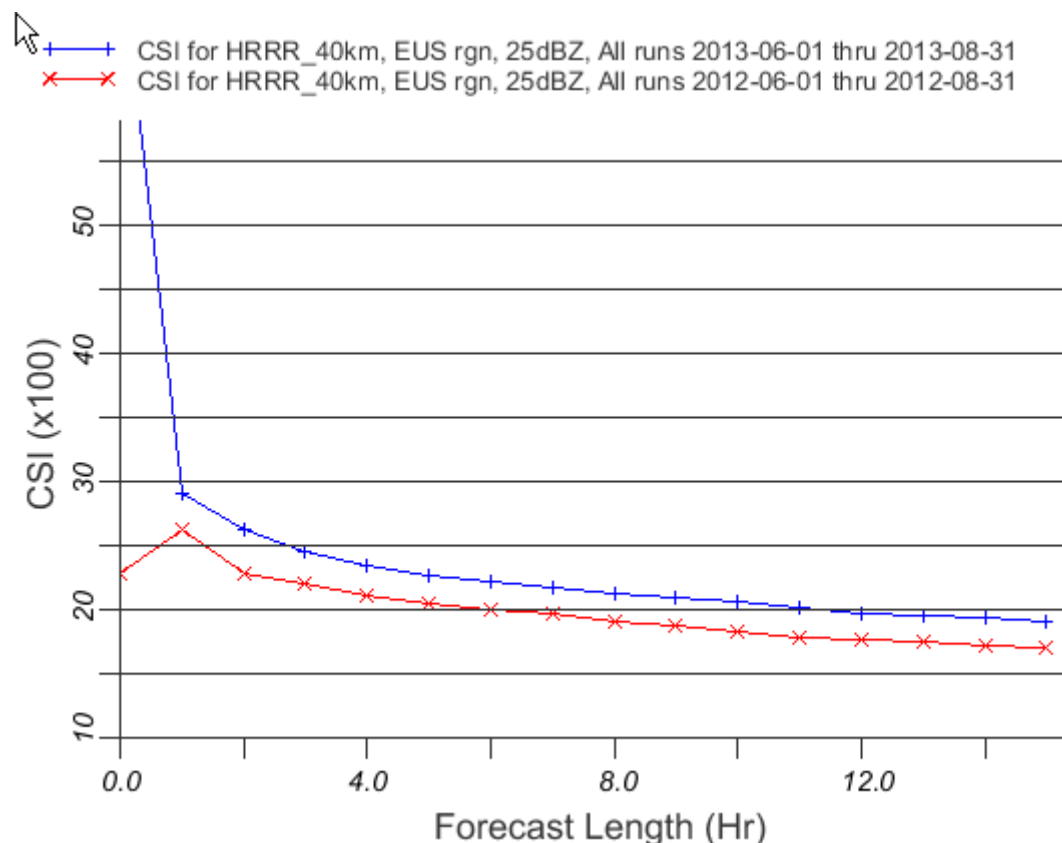




*Fig 2. Comparison of RAP reflectivity forecasts with and without 3-km radar assimilation.*

### 3. HRRR forecast skill for 2013

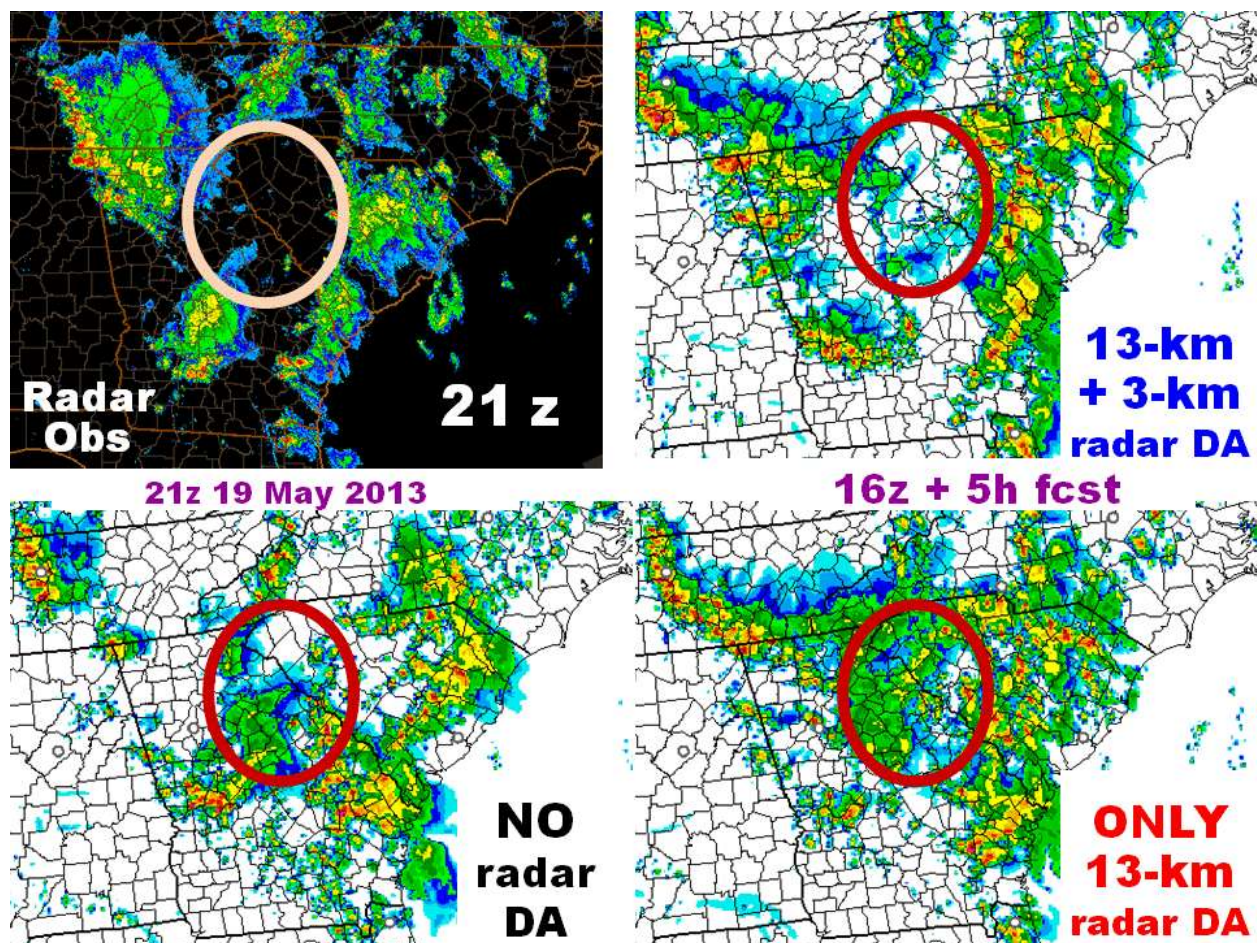
Overall, the HRRR performed quite well during the 2013 warm season evaluation. Many examples of good forecasts were noted by many users from the aviation and other communities. Indeed, HRRR use continued to increase and expand and users definitely noticed the improvements in short-term forecast skill. These improvements were also seen in verification statistics. While we did not have the computer resources to run 2013 and 2012 HRRR versions simultaneously, we present here seasonally matched comparisons between the 2012 and 2013 HRRR. We note that while differences in mean weather conditions between 2012 and 2013 may affect this comparison, 2013 vs. 2012 statistics computed from a long time period (4 months, June-July-Aug.-Sept.), should reveal the impact the model upgrades. Fig. 2 shows such a comparison\, Critical Success Index (CSI) scores for the 2013 vs. 2012 HRRR. As can be seen, the 2013 HRRR shows higher CSI scores through the entire forecast length; with a strong pickup for short forecast lengths.



**Fig 3. Comparison of HRRR forecast reflectivity CSI scores (25 dbz, upscaled to 20-km) verified over the Eastern part of CONUS for 2013 version (blue) and 2012 version (red) Hourly reflectivity verification is computed over a 4-month period (JJAS) from 2012 (for the 2012 HRRR) and 2013 (for the 2013 HRRR).**

A sample forecast comparison is now shown to help illustrate the forecast improvement for the 2013 HRRR. Fig. 4 shows +5 hour HRRR forecasts valid May 19, 2013 for retrospective HRRRs 1) with the 13-km and 3-km radar assimilation (similar to 2013 HRRR), 2) with only the 13-km radar assimilation (similar to 2012 HRRR), and 3) with no radar reflectivity assimilation. The results show that without any radar assimilation, storms are generally not in the correct locations. With only the 13-km assimilation, storm-coverage is too great, making it more difficult for the user to identify key convective areas. Only with both the 13-km and 3-km radar reflectivity assimilation, does the model capture the key no radar echo region in NE GA / NW SC.



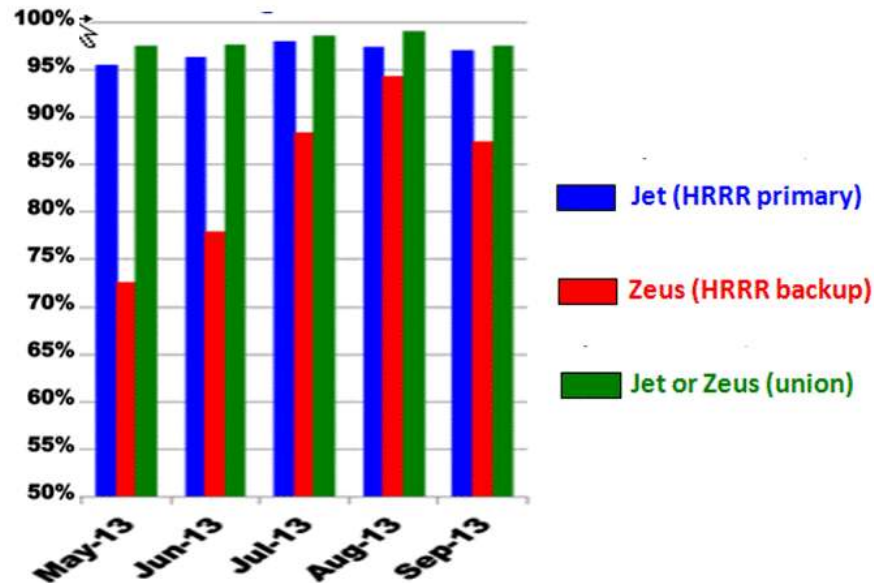


*Fig 4. Comparison of +5 hr HRRR forecast reflectivity for HRRR runs with 13-km and 3-km radar reflectivity assimilation (similar to 2013 HRRR), with only 13-km radar (similar to 2012 HRRR) and with no radar assimilation.*

#### 4. 2013 HRRR RUN RELIABILITY

The HRRR ran with very high reliability during the 2013 warm season evaluation, easily topping the 95% for the summer for the “fewer the two missed runs”. A graph of the monthly run availability percent (excluding two or fewer consecutive missed run) is show in Fig. 5. A more detailed summary of the reliability statistics for each month is given in appendix B.

### HRRR 12 hr Forecast Availability Excludes two (or fewer) consecutive missed / incomplete runs



*Fig. 5 HRRR reliability by month with allowance for up to two consecutive missed runs. The blue bar shows the reliability for the Jet-based HRRR primary, while the red bar shows the Zeus-based HRRR backup, and the green bar shows the combined score.*

#### 5. 2013 HRRR internal assessment summary

The HRRR ran with very high reliability during the 2013 warm season evaluation and produced many fine forecasts, as evidenced in the skill score improvement from 2014. This change package for the RAP has been transferred to NCEP and is now in final testing with an NCEP operational upgrade planned for late in 2013 and an initial HRRR implementation early in 2014.

### Appendix A: ESRL RAP/HRRR updates - Jan-Apr 2013

Effective concluding with the 23 UTC 06 April 2013 cycle the ESRL/GSD RAP and HRRR have been upgraded to include the following data assimilation and model changes:



